CONCRETE
CONSTRUCTION

P O BOX 444 ELMHURST ILLINOIS TERRACE 4 5110

JANUARY 1961

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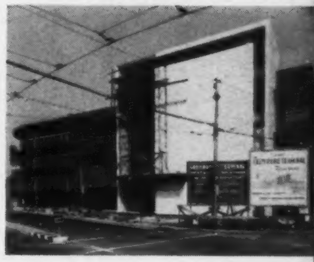
Published monthly and copyrighted © 1961 by Concrete Construction Publications, Inc. Accepted as controlled circulation publication at Chicago, Illinois. Individual subscriptions at the rate of \$5.00 per year, \$9.00 for 2 years (U.S.A.); \$10.00 per year (foreign). Single copies \$1.00. Bound volumes of previous years' issues, when available, at \$10.00 (U.S.A.), \$15.00 (foreign). Subscription and bound volume orders must be accompanied by check or money order.

COMING NEXT MONTH

Cement Mason's Manual—Part IV. The February installment in this series takes up in considerable detail the specific problems peculiar to concreting operations in both cold weather and hot weather.



Lightweight Structural Concrete. The second article in our series on lightweight concretes will deal specifically with structural mixes involving such aggregates as expanded clay, shale, slate and slag.

Grouting Under Water. Proper use of accelerating admixtures can produce grouts which will set in 3 to 4 minutes under water. This article will describe work done with materials of this type in repairing Florida seawalls.

Over 36,500 copies mailed. Edited for all who are concerned with quality, job placed concrete (including prestress, tilt-up, lift slab, and thin-shell)—its specification, production, handling, forming, reinforcing, placing, finishing and curing: *Concrete Contractors, General Contractors, Engineers, Architects, Industrial Construction and Maintenance Men, Highway Engineers, Ready-Mix and Prestressed Concrete Producers.*

About our page numbers: The pages of Concrete Construction Magazine are numbered continuously from January through December each year as a means of facilitating the use of bound volumes for reference purposes.

cold weather concreting

After concrete is in place it should be protected against freezing. The strength of concrete that has been subjected to a single freezing cycle at an early age can be restored to normal by resumption of favorable curing conditions. But such concrete will not have the resistance to weathering nor will it be as watertight as concrete that has not been frozen. Where several cycles of freezing and thawing occur at an early age, strength and other qualities are permanently affected. This is one of the reasons why such flatwork as sidewalks and driveways placed late in the fall sometimes deteriorate within a few years. Most problems can be minimized by the following precautions:

1 PLAN IN ADVANCE

Have equipment and materials ready before cold weather arrives.

Provide heaters, insulating materials and enclosures.

Use high-early-strength concrete where job conditions make it desirable.

2 HEAT THE MATERIALS

The temperature of the concrete as it is placed in the forms should be between 50 and 70 deg. F. for slabs.

When air temperatures are between 30 and 40 deg. F., the mixing water should be heated.

When air temperatures are below 30 deg. F., the mixing water and sand (and sometimes coarse aggregate) should be heated.

No frozen aggregate lumps should be in concrete at the time it is placed.

To prevent flash set, materials should not be overheated. Maximum allowable water temperature is about 140 deg. F.

Do not place concrete on frozen ground—unequal settling will occur when the ground thaws.

Fresh excavations should be covered with straw or other insulating material to prevent the ground from freezing until concrete can be placed.

Remove all ice and frost from forms and steel reinforcing.

3 USE ACCELERATORS CAREFULLY

Use about 1 lb. of calcium chloride per sack of cement to hasten hardening. Not more than 2 lb. should ever be used because of danger of flash set.

Don't use any admixtures to prevent concrete from freezing.

Don't use calcium chloride with other admixtures which accelerate hardening.

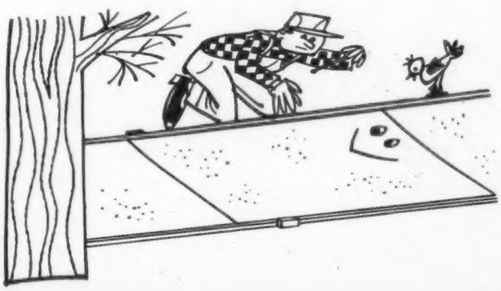
4 PROVIDE SUITABLE CURING TEMPERATURES

Maintain temperature of concrete, when using normal portland cement, at 70 deg. F. for 3 days or 50 deg. F. for 5 days.

Maintain temperature of high-early-strength concrete at 70 deg. F. for 2 days or 50 deg. F. for 3 days.

Do not allow concrete to freeze during next 4 days.

Cool concrete *gradually* at rate of 1 to 2 deg. per hour until it reaches the outside temperature.



5 KEEP JOB CONDITION RECORDS

Record date, hours, weather conditions and temperature (both of air surrounding concrete and surface of concrete) at least twice daily.

6 PROTECT CONCRETE

Insulation, such as with a thick blanket of straw, without artificial heat is often sufficient protection for slabs on ground.

At lower temperatures housing and artificial heat are necessary.

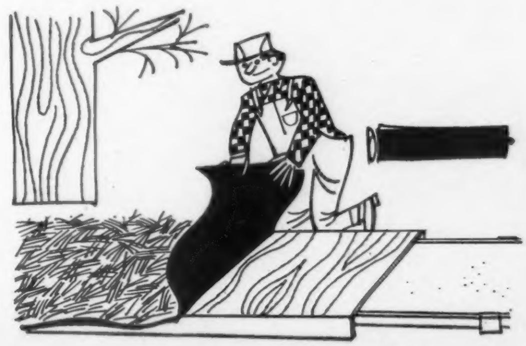
Housings can be made of wood, insulation board, waterproofed paper or tarpaulins over wood frames.

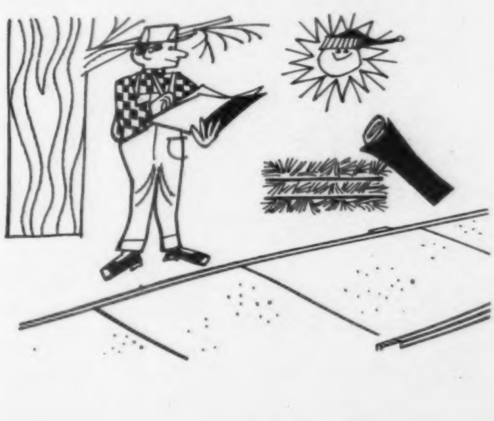
Circulate moist warm air between floor slabs and housing.

Avoid the risk of fire by placing coke or oil-fired heating units away from flammable material. Vent to outside.

Raise heating units above the floor to avoid rapid drying of concrete underneath.

Keep concrete moist, especially near heating units. In cold weather when artificial heat is applied, moisture for curing is still very important. First wet the slab well with water and cover with waterproof paper. Then apply heat to keep from freezing. This water treatment, along with covering, prevents the surface of the slab from drying out.





hot weather concreting

Concreting in hot weather poses some special problems. Among these are strength reduction and cracking of flat surfaces due to rapid drying. Concrete may stiffen before it can be consolidated because of rapid setting of the cement and excessive absorption and evaporation of mixing water. This leads to difficulty in the finishing of flat surfaces.

Most of these problems can be minimized by the following precautions:

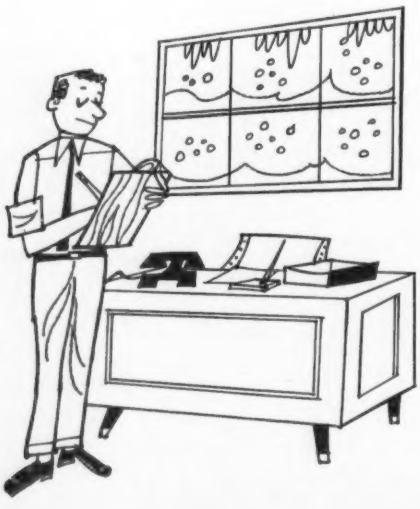
1 PLAN AHEAD

Be prepared with necessary equipment and material well in advance of hot weather.

Be sure of an ample water supply for sprinkling subgrades, wood forms and aggregates, and for curing.

Have tarpaulins or polyethylene sheets and lumber ready for sunshades and windbreaks.

Schedule work so that concrete can be placed with the least delay. Jobs could be started late in the afternoon during extremely hot periods.



2 USE COOL MATERIALS

Use concrete which has been chilled during preparation. Stockpiles of coarse aggregate should be sprinkled with water to cool the aggregate by evaporation. Mixing water should be chilled in very hot weather by refrigeration or by using ice as part of mixing water. The ice should be melted by the time concrete leaves the mixer.

3 PREVENT ABSORPTION

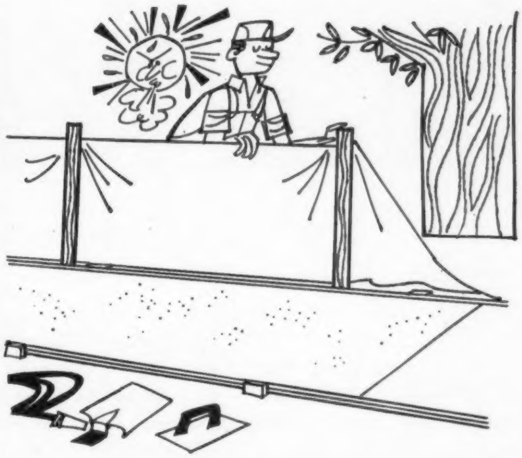
Sprinkle subgrade and wood forms just before placing concrete so they will not absorb water from the mix.

Coarse aggregates should be sprinkled before they are added to the batch.

This article is an authorized reprint from the *Cement Mason's Manual*, a new publication of the Portland Cement Association.

4 PROTECT AGAINST EVAPORATION

Erect windbreaks to prevent strong, hot winds from drying exposed concrete flatwork surfaces while they are being finished.



5 PLACEMENT AND FINISHING

Don't delay in placing concrete. Strike it off and darby it at once.

Place temporary covers, such as burlap kept continuously wet, over the fresh concrete immediately after striking and darbying.

When ready for final finishing, uncover only a small section immediately ahead of the finishers. Cover again at once after final finish and keep the cover wet.

Any delays in finishing air-entrained concrete in hot weather usually lead to the formation of a rubber-like surface which is difficult to finish without leaving ripples or ridges.

6 CURE IMMEDIATELY

Start curing as soon as surfaces are hard enough to resist marring.

If curing compound is to be used, apply it immediately after final finishing. See that adequate and uniform coverage is obtained. In extremely hot weather it is advisable to cover the slab with water for 12 hours before using curing compound.

Keep the concrete surface *constantly* wet to avoid alternate wetting and drying during the curing period.

Continue curing for at least 7 days. Water not only acts as a curing agent but also cools the slab.

SHELL FOUNDATIONS

By J. FRED TRIGGS, D.Sc. P.E.*

WHAT CAN POSSIBLY BE DRAMATIC about a foundation? Foundations are by their very nature prosaic. They perform a utilitarian function, they transfer the loads collected by and originating within the structure to the supporting soil and they do it quietly and without fanfare. They are, in a word, self-effacing.

But shell foundations are different.** Although they, too, have performed their function well and quietly, because of their unique nature they have been argued against and noisily championed by construction men, college professors, engineers and sidewalk superintendents.

The overriding virtue of the shell foundation is its capacity to distribute loads of considerable magnitude with low intensity of soil pressure, with an economy of materials and without introducing into the foundation structure excessive bending moments and shearing stresses. How this virtue is developed today is the subject of this article.

The writer has designed shell foundations for many different types of soil conditions ranging from elastic strata overlying mine voids to water-bearing unconsolidated silts, and touching on the way, filled soils ranging from dumped foundry sand to uncompacted clays. Each of these problems has presented new challenges, but each has found solution in the technique of thin shell foundations.

FILE: Foundations

*The author is a consulting engineer with offices in Pittsburgh, Pennsylvania.

**See "Thin Shells Go Underground," Concrete Construction, July, 1960, page 198.

the hyperbolic paraboloid inverted umbrella

The type of thin shell foundation utilized for all of these solutions has been the hyperbolic paraboloid inverted umbrella. Although reasons for the selection of this shape were not always compelling, they would appear to be logical considering all factors. For example, barrel shells or folded plates might just as well have been used where loads were collected by walls and introduced to apexes of pyramids by grade beams. However, both of these solutions would encounter forming and screeding difficulties. In the case of loads introduced to foundations by columns, the inverted umbrella shell is, of course, ideal.

In any case, the inverted umbrella has many qualities not possessed by other thin shells, namely:

1. Its curvature is generated by straight lines and therefore it is easy to form and practical to screed.
2. Its edge beams, normal components of any shell, are integral to its shape and need not be separately formed for casting.
3. Its shape (see diagram) collects and dissipates loads without introducing secondary stresses which could complicate the functioning of the underlying soil plane.
4. It lends itself to exact computation of internal stresses based upon statics and is determinant and non-redundant.

It may be well to explain shell technology and also what a hyperbolic paraboloid inverted umbrella is. Shell technology is the empirical science of evaluating membrane stresses in structures of

Ready mixed concrete was used in the shell footers for the Haines Super-Market near Pittsburgh. Believed to be the first use of the h/p foundation in this country, this project was designed by Dr. Triggs.

curved shape. We have been told that pound for pound the egg shell is the strongest natural structure; that enlarged 500 times, the egg shell would span 125 feet and measure in thickness less than four inches. However, even the egg shell leaves much to be desired as the perfect structural shape. This perfection of structure requires a curvature which is doubly opposing and is achieved only in the hyperbolic paraboloid figure. Due to the physical limitations of its method of production, the egg shell cannot, of course, achieve this doubly opposing curved surface.

the hyperbolic paraboloid

A hyperbolic paraboloid is a warped surface having these geometric characteristics:

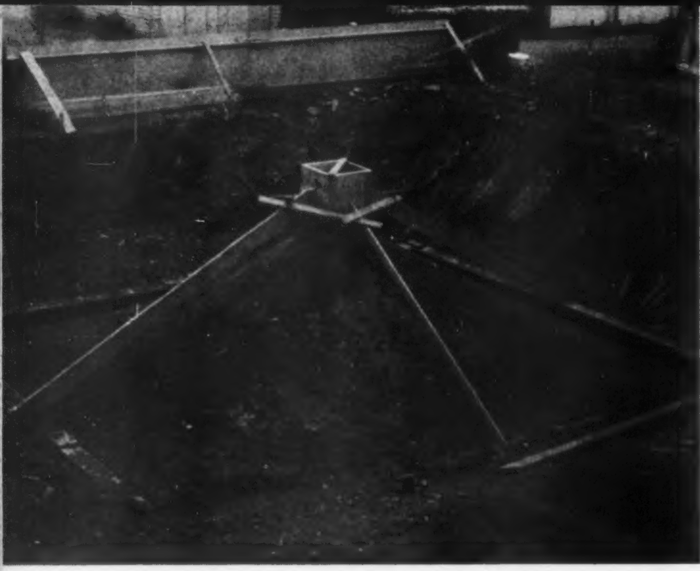
1. A flat plane is warped by depressing two opposite corners and elevating the other opposite corners leaving the center fixed in its original position.
2. The edges of the figure continue to be straight lines but slope to conform to the elevations and depressions resulting from raising and lowering adjacent corners.
3. The genetrices of the curves are straight lines connecting opposite edges varying in slope as the elevation of the edges vary.
4. The resulting paraconcaves in an upward direction slide along paraconcaves in a downward direction.
5. If the shape is cut by a horizontal plane, the intersection will be hyperbolic.

Therefore, a hyperbolic paraboloid is the surface of a figure composed of opposing parabolas which are generated by straight lines of varying slopes and fixed vertexes.

The quality which gives the hyperbolic paraboloid form its great structural strength is that the entire shape is made up of two sets of parabolic arches, each set normal to the other and each of the same shape but of opposite sign. This produces a situation in the structure in which all uniform loads generate forces in the shape which are always in equilibrium. For instance, it is evident that any given uniform load on the shell is carried by two arches normal to each other with each arch carrying load of intensity equal to $\frac{w}{2}$. The mid span simple beam bending moment due to this uniform load is $\frac{w}{2} \times \frac{L^2}{8}$. There is still another force, however, acting on the arch which is the horizontal thrust "h," which when multiplied by the lever arm "b" or height of the arch also produces a mid span load moment equal to $\frac{w}{2} \times \frac{L^2}{8}$ but opposite in direction. Therefore, the net bending moment at any point on the surface due to uniform load equals zero.

the umbrella

A hyperbolic paraboloid umbrella is a shape formed by abutting four hyperbolic paraboloids in rectangular figure. All stresses to which it may be subject can be concentrated vertically at the point of intersection of the four hyperbolic paraboloids. These forces will consist of the compressive stresses resolved along the edge beams and directed vertically into the supporting column in accordance with their components and in con-



These views show three stages in the construction of inverted h/p foundation umbrellas for All Saints School in Etna, Pennsylvania. The design was used in this instance because of an exceptionally low soil bearing capacity. In the finished structure five shell foundations support the same number of conventionally positioned h/p umbrellas.

formity with the laws of statics.

If the hyperbolic paraboloid is made up of two sets of parabolic arches, each normal to the other, it is evident that along the edges where these arches intersect, the components (normal to each) of horizontal thrust "h" are equal in magnitude but opposite in direction. Therefore, there can be no force normal to the edges. However, the components of "h" parallel to the edge all act in the same direction to produce a shearing stress along the edge equal to $\frac{w}{2k}$. This stress in combination with the vertical component of arch thrust creates pure compression in the edge beams of adjacent hyperbolic paraboloids and tension in the free edges of the umbrellas. The peculiar phenomenon of compression in adjacent edges and tension in opposite edges arises from the shape of the arches, which, when curved upward, produce tension and, when curved downward, produce compression.

Since the transferred forces in the membranes of the hyperbolic paraboloids are resolved in the edge beams of these shapes in accordance with the shape of the parabolas, it is evident that the forces along the free edges of the hyperbolic paraboloids will be tensile stresses and that the forces along the confined edges of the hyperbolic paraboloids, where they abut the adjacent hyperbolic paraboloids, will resolve into compressive stresses. We thus have a quadrilateral figure of the four hyperbolic paraboloids supported at the point of intersection with all forces directed to the center of the shape.

The magnitude of compressive forces in the edge beams forming the ribs of the umbrellas and tensile forces along the free edges of the umbrella can be computed very simply based upon uniform live and dead loads and the ratio of depth to length and breadth of the hyperbolic paraboloids by strict laws of statics.

the roof umbrella

Our discussion of the evaluation of stresses in the shell has ignored thus far the direction of application of the loads. In order to more adequately illustrate the design concept of inverted hyperbolic paraboloid umbrellas used as footers, it is more convenient to consider first the idea of the umbrella as a roof structure. This concept of the hyperbolic paraboloid umbrella constructed of reinforced concrete forming a roof structure presumes that all imposed loads are collected by the slabs comprising the umbrella and transferred by membrane stresses (shear) to edge beams which form the four ribs of the umbrella. These

ribs act as columns in compression to bring the collected loads to a central point, while the periphery of the umbrella is composed of edge beams which act in tension to hold the figure together. Reinforcing steel is utilized to take all tension while compression is taken by tied steel rods and a thickened concrete section. The entire umbrella rests on a reinforced concrete column.

the inverted umbrella as a footer

The same design concept is used for the inverted umbrellas which constitute the footer, but in this case, the load is concentrated by the column and dispersed by the inverted umbrella as a uniform soil pressure of low value. In the case of the roof umbrella, symbol "w" is used to indicate total live and dead load per unit while the same symbol in the inverted umbrella identifies soil pressure. Otherwise all stress computations remain identical in all respects.

the All Saints School

Very often the most difficult task of the pioneer in any field is to secure acceptance of a new or unusual technique by the person buying the product, even though the purchaser may be getting a bargain. The writer's design of the All Saints School building in Etna, Pennsylvania, consisted of five h/p umbrellas, each resting on inverted h/p foundation umbrellas. The necessity for this kind of design arose from the quality of soil bearing of the site which could support no more than 500 pounds per square foot of footer area.

One of the foremost soils experts in the country was enlisted by the skeptical owner to review the design. Dr. D'Appolonia commented as follows: "The proposed footing imposes an average pressure on the silt of 250 pounds per square foot. This silt deposit can sustain this low soil pressure without serious settlement."

On this project, five roof umbrellas, four of which measure 45 feet by 58 feet and one 57 feet by 63 feet 4 inches, are supported by 25- by 30-foot and 30- by 34-foot inverted umbrellas. The thickness of roof shells is 4¼ inches and footer shells are 4½ and 6½ inches respectively.

Excavation specifications required that the contractor shape his digging accurately to the underside of the umbrella, but this was not always possible. Actually, the exact shape was secured by the use of a template frame and a dry mixture of one part cement to eight parts granulated slag, well tamped to the contour of the bottom of the shell. This template served later as a bounding form for the free edges of the footer, and its pyramidal supports as screed boards for shaping the top surface of the mat. Concrete in the shell was placed from the outside in toward the center and the top.

Farrell low rent housing project

Engineers for the Housing and Home Finance Agency of the Federal Government are guided in their appraisal of engineering techniques by manuals which specify and stipulate what is good engineering practice. Naturally enough, the authors of these manuals were not acquainted with the use of shell technology for foundations. Nevertheless, the Government engineers, when confronted with analytical estimates of the savings to be achieved by the use of h/p footers on Public Housing Project PA 20-7 at Farrell, Pennsylvania, closed the books and approved this method of construction for the project.

The site for this low rent housing project had been the disposal area for process sand used in an iron foundry. The depth of spent foundry sand reached a maximum of 53 feet, but the sand fill was confined at its low end by a stable compacted earth fill which constituted in a sense an arched dam.

Methods considered and cost analyzed were drilled piers and grade beams, spread wall footers and umbrellas with grade beams. The shells were selected as the most economical solution to the problem. One hundred and sixteen inverted umbrellas, each 9 feet square, were constructed on this project.

A minor variation in the conventional method of shaping mounds for umbrellas had to be adopted on this job. The cohesionless character of the foundry sand precluded the shaping of mounds for the shell contour. Clay having good compaction characteristics was imported and mechanically tamped in 3-inch layers to the desired contour of the underside of the shell footers.

conclusion

Colleagues have suggested many modifications of the techniques employed on the projects described here. One modification that would seem to have merit for supporting walls and floor slabs carrying considerable loading on weak soil is to provide drilled piers to solid bearing and to surmount each drilled pier with an upright h/p umbrella. The umbrella filled with granulated slag or other compacted material would then collect the loads and transmit them economically to the caps of the drilled piers, thus eliminating heavy slabs and grade beams. Undoubtedly readers of this magazine will envision many other modifications and uses for this technique. END

Readers who would like to receive calculation sheets covering the design of a hyperbolic paraboloid umbrella may request them by writing on their business letterheads to Concrete Construction Publications, Inc., P. O. Box 444, Elmhurst, Illinois.

In this fairly typical modern lightweight aggregate manufacturing plant the rotary kiln is located at the left while the stockpiles for the storage of various sizes of finished material are located at the right.

LIGHTWEIGHT CONCRETE ... a general view

DURING RECENT YEARS, a number of materials known as lightweight aggregates have played an increasingly important role in the concrete industry. Lightweight aggregates, used to produce lightweight concretes and plasters, have for some time been valuable in the manufacture of precast concrete. As builders have come to realize that savings in weight can equal savings in total cost, the lightweights have steadily gained prominence in the production of structural, roof deck fill, and insulating concrete.

Among lightweight aggregates are expanded slags, expanded clays, shales, and slates, perlite, and vermiculite. Slag, clay, shale, and slate aggregates are used in structural concrete and for fill and insulating purposes. Perlite and vermiculite—the ultralightweights—come into play generally for insulation and fill work, although these materials may also be used with heavier aggregates to form high strength floor fills.

Lightweight concrete pays dividends from the second story up, and under the proper conditions economy can also be realized with one-story structures. Plans for a Cleveland department store, for example, at first called for three stories; but due to the use of lightweight concrete, ten more floors were added.

Designers of Milwaukee's War Memorial utilized lightweight concrete in large cantilevered sections, and realized a saving of 12 percent in structural volume and a whopping 40 percent in total weight. By employing lightweight concrete, the builders of Chicago's 42-story Prudential Building saved 17,000 tons of deadweight.

FILE: Lightweight Concrete

Office and apartment buildings, and other multistoried structures, all present opportunities to take advantage of savings in steel and total weight afforded by lightweight concrete. The same is true of long span bridges, such as the Tacoma Narrows suspension bridge. There, lightweight concrete accounted for considerable saving in structural steel and cable costs.

The utilization of lightweight concrete in the United States began about 1900, with cinders from coal-burning furnaces and locomotives as the aggregate. The introduction of lightweight concrete coincided with changes in building design. Heavy, load-bearing walls and columns gave way to structural steel frameworks, bringing the skyscraper and the long span bridge.

The first processed lightweight aggregate was produced by Stephen Hayde of Kansas City, just prior to World War I. Hayde developed a method to bloat certain clays and shales under intense heat. He patented his product under the name Haydite, an aggregate still widely produced and marketed today.

Although special work on developing a technique for expanding slag had been done in Germany with some success during the 1920's and early '30s, slag processors in the United States did not become interested until later. The first year for which the U. S. Bureau of Mines records any statistics covering production of expanded slag was in the Minerals Yearbook for 1943, when it was reported that 76,971 tons of expanded slag was produced. From here on, the increase was rapid; by 1944 the reported tonnage amounted to 165,822—more than double the previous year—and by 1945 it reached 234,107 tons. The 1959 report of the Bureau of Mines shows a total of 2,812,000 tons of expanded slag.

Vermiculite concrete was used in buildings as early as 1938, and numerous manufacturers began to place manufactured lightweight aggregates on the market after 1947. In that year there were only seven plants producing expanded shale lightweights; by 1950 there were fifteen more. In 1959 the total number of producers of various kinds of lightweight aggregates was 250. The output of all lightweight aggregates was estimated at 15.1 million tons. Much of the production goes into the manufacture of masonry units, but the use of lightweight aggregates in cast-in-place structural, insulating, and fill concrete continues to increase.

Expanded slag, clay, shale, and slate aggregate concretes are generally classified as structural lightweights, ranging in weight from 85 to 115 pounds per cubic foot. Perlite and vermiculite concretes are ultralights, some types weighing as little as 20 pounds per cubic foot.

Expanded slags are by-products of the blast furnace, made by treating molten slag with controlled amounts of water. Depending on the amount of cement used, expanded slag aggregates will yield concrete of a structural strength of 4000 psi and better.

The expanded clays, slates, and shales begin as products of the earth. They are processed by crushing, then heating to about 2000 degrees F. until the particles swell. Expansion varies from as little as 3 percent to as much as 20 percent. The result is a pelletized product with a hard, impervious coating and a porous interior. Concretes made of expanded clays, slates, and shales can have compressive strength in excess of 6500 psi.

Perlite and vermiculite are obtained by mining. Perlite is a volcanic glass that expands to frothlike particles when subjected to temperatures of about 1800 degrees F. Vermiculite is a hydrate form of mica which expands extraordinarily on heating, up to fifteen times its original size.

Concrete composed of perlite and vermiculite is too weak for normal structural work. Perlite concrete will have a maximum compressive strength of 1000 psi and concrete made with vermiculite a maximum of 500 psi. However, ultralightweight concrete is excellent for base coat Portland cement plaster, pipe and wall insulation, and fire protection; and it has proven valuable in roof-deck and floor-fill construction as well.

Lightweight concrete might be compared with conventional sand and gravel aggregate concrete on the following points:

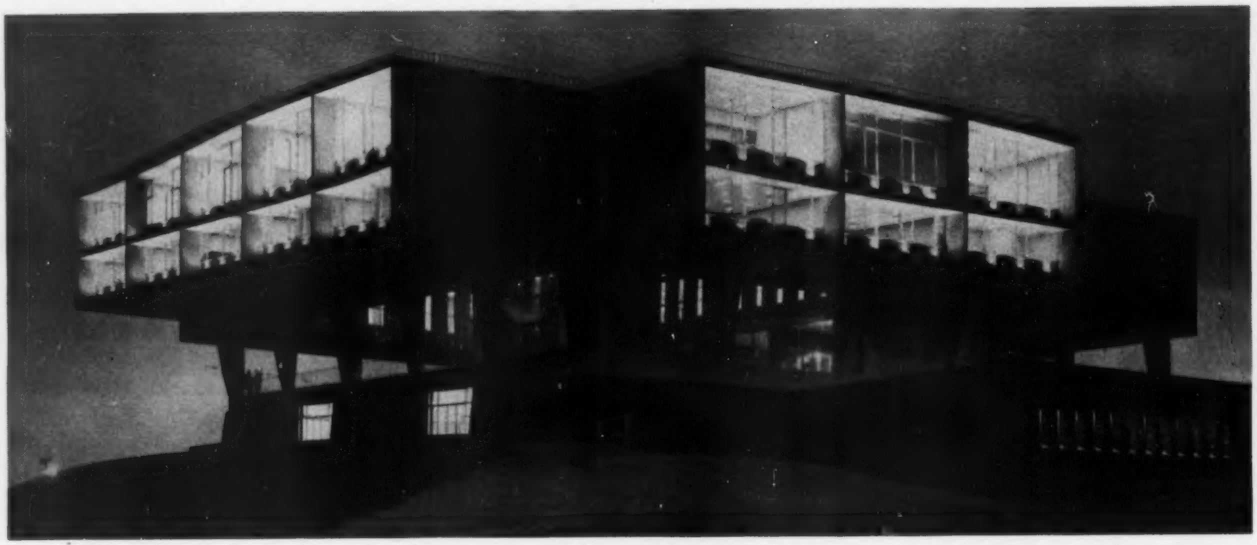
1. Lightweight concrete ranges in weight from 20 pounds per cubic foot for the lightest insulating and fill concrete to 115 pounds per cubic foot for structural grade concrete. Most conventional concrete runs around 150 pounds per cubic foot, although air-cooled slag concrete weighs in at around 140 pounds for standard mixes, and may run as little as 130 pounds for mixes containing entrained air.

2. Lightweight structural compressive strength varies from 500 psi to 1000 psi for insulating material to 7000 psi and better for structural concrete. Normal weight concrete ranges to 8000 plus psi.

3. The modulus of elasticity varies from around 65,000 psi for the ultralightweights to 3 million psi for the medium lightweight concretes used for structural work. Generally the modulus of elasticity for lightweight concretes is about one-half to two-thirds that of gravel, stone and air-cooled slag concretes of equal strength.

4. Lightweight concrete shrinkage also varies according to the aggregate, being about 0.1 to 0.2 percent for perlite, from 0.1 to 0.7 for vermiculite, from 0.04 to 0.06 percent for expanded slag, and from 0.02 to 0.08 percent for shale, slate and clay. Conventional concrete shrinkage ranges from 0.04 to 0.08 percent.

5. The thermal conductivity of lightweight con-



One of the outstanding structures of cast-in-place lightweight concrete in recent years is this striking War Memorial Building in Milwaukee, Wisconsin.

crete, in BTU per hour per square foot per degree F. per inch, ranges from 0.6 to 0.97 for vermiculite, 0.5 to 0.9 for perlite, 1.5 to 3.0 for expanded slag, and 2.0 to 4.0 for expanded clays, slates and shales. Sand and gravel thermal conductivity runs from 8.0 to 12.0.

6. The fire resistance of lightweight concrete has been demonstrated by fire tests to be superior to sand-gravel concrete. Fire tests for reinforced concrete floor sections, conducted by Fire Underwriter's Laboratory for Portland Cement Association, show a 4-hour rating for 4½-inch slabs with expanded slag aggregate as against only a 3-hour rating for 6-inch slabs made of trap rock, crushed limestone, and gravel aggregates.

The use of lightweight concrete presents some problems. Its lower modulus of elasticity means increased deflection. The light weight and porosity of lightweight particles require special treatment in structural use. And lightweight aggregates cost more than natural aggregates, in some cases three or four times as much, and generally at least twice as much.

However, there are factors to consider in lightweight besides the saving in steel and weight that often can offset the higher cost of the aggregate. Lightweight works a saving on the ground as well as in the air: it makes for more economical transportation of ready mix since the lighter weight makes it possible to load even the largest trucks to full capacity, and there is, of course, less wear and tear on the trucks. The excellence of lightweight concrete's insulating and fire-proofing properties gives it twice to as much as twenty times the insulating quality of conventional concrete. Lightweight concrete also has good acoustical properties due to its open texture. It provides architects and engineers with flexibility to consider new, cost-saving building techniques, such as barrel, paraboloid, folded plate, and other thin shell roof designs, besides varied patterns resulting from exposed aggregates and form liners, and new colors being incorporated into concrete. And finally, its lower modulus of elasticity permits lightweight concrete to tolerate shrinkage stresses with less difficulty than normal weight concrete.

The following is a check list of desirable characteristics of lightweight concrete. Some may be of greater importance than others, depending on job specifications:

1. There should be uniformity in properties and composition.

2. The aggregate should be suitably graded for the intended use, in accordance with the appropriate ASTM specification.

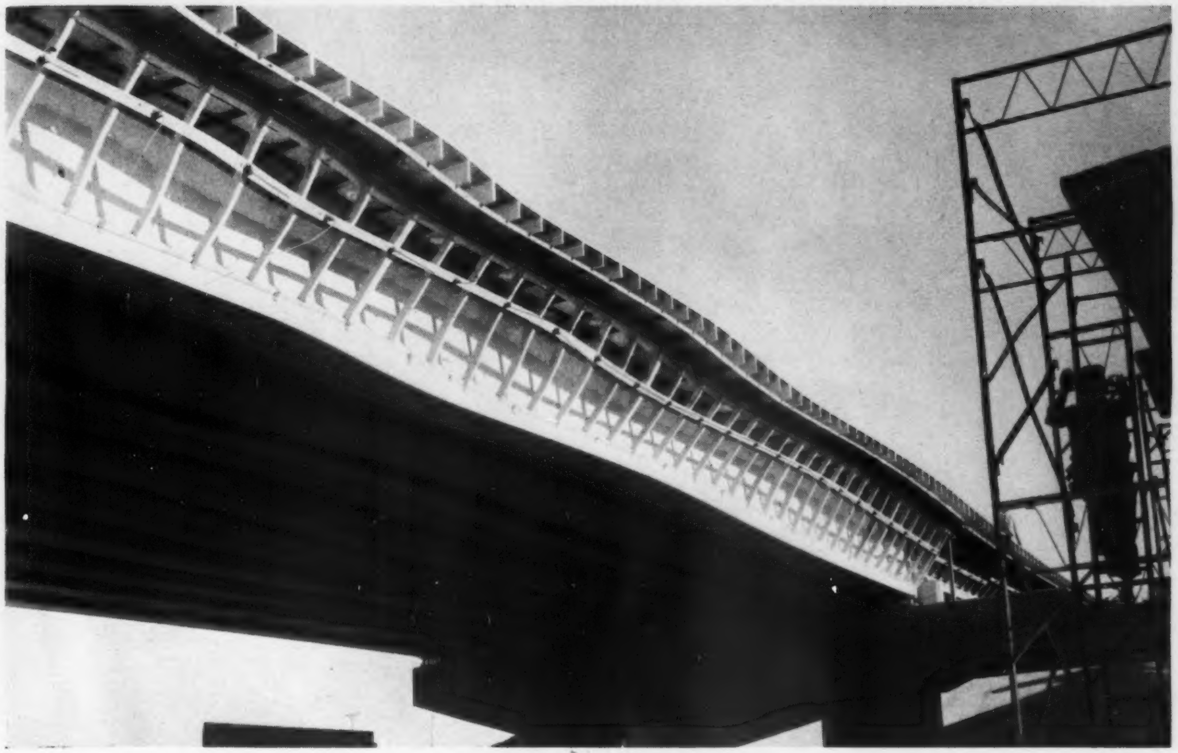
3. The aggregate should have a low specific weight to insure worthwhile savings in the structure, in accordance with the appropriate ASTM specifications.

4. Notwithstanding the desirability of having surface characteristics to provide good bond, the aggregate should have a minimum of large external voids but a large number of smaller well-dispersed voids throughout the particles.

5. Individual pieces of aggregate should be strong enough to withstand handling and mixing.

6. The particles should bond well with cement and not react chemically to cement.

This article has dealt with the general aspects of lightweight concrete. Subsequent articles will discuss structural concretes made of expanded clay, shale, slate, and slag lightweight aggregates; and fill and insulation concretes composed of perlite and vermiculite aggregates. END



New Mexico Contractor Says Symons Forms Simplest to Use

Curb Forming on Bridge with Symons Steel-Plys

When J. W. Construction Company, Albuquerque, New Mexico, was planning the construction of a bridge over the New Mexico 422 Freeway running through Albuquerque, management looked carefully at available forms for curb forming on the bridge. The basic demand was for a form that is easy to use. Symons Steel-Ply Forms met this requirement. Bill Place, concrete superintendent, had this to say: "There are several forms on the market, but we have found Symons the simplest to use for our purposes."

The bridge on which Symons Steel-Ply Forms are being used is over Manuel Street, S.E.

Credit for the sale goes to John Hughes and Bus Edgerly of McCaffrey-Way Co., the Symons distributor in Albuquerque. The contractor is not only pleased with the forms, but is enthusiastic about the excellent service received from McCaffrey-Way.

Wherever Symons Steel-Ply Forms are used, the contractor shows extreme satisfaction with results. Here are some of the reasons why . . . improved lightness and durability, strength and handling ease, all are contributing factors to forming concrete without blemishes from air pocket holes, segregation and rock products. And Symons Steel-Ply Forms do not spread, buckle, swell or leak.

Symons Steel-Ply Forms are rented with purchase option.

Symons CLAMP & MFG. CO.

4271 Diversey Avenue Dept. A-1 Chicago 39, Illinois

Warehouses throughout the U.S.A.

MORE **SAVINGS** FROM **SYMONS**

Economical Housing With Concrete Sprayed Over Steel

A CONCRETE BUILDING PROCESS involving skyscraper construction techniques bears promise of making a nationwide impact on the residential housing industry. The concrete-steel process is effecting so many economies that the developers are offering home buyers in Largo, Florida, extras impossible to match at the price of comparable housing. Savings are said to run as much as $2,000 per house.

A Uni-Con house starts with a site-cast concrete floor slab. The reinforcing steel in the slab is stubbed about 12 inches above floor level. To these stubs are welded ⅝-inch steel rods into framework that embraces interior and exterior walls and the roof, until the embryo house appears like a huge birdcage.

To this skeletal framework is welded a gridlike maze of ⅜-inch steel rods, in squares about 12 to 14 inches on a side. These rods are wired or welded together and bent to form roof ridges and wall corners. Against these are positioned slabs of polystyrene insulation, blocked away from the rods about an inch by small wood cleats.

Upon this steel birdcage is sprayed a 1-inch coat of concrete. The walls are subsequently built up to a thickness of 5 inches by a succession of three more 1-inch applications of concrete and a plaster textured finish applied on interior surfaces.

No wood is used (except in doors and kitchen cabinets) so the houses are termite and rot-proof. With the monolithic construction and the interlocking support of the steel rod skeleton and concrete, the houses are believed to be able to with-

Inventor points out that his steel and concrete home is $2,000 to $3,000 cheaper than homes of comparable size and appointments, as well as much safer to live in. Appearance of stone masonry beneath front windows is simulated by scoring concrete with a tool and filling grooves with black mortar.

RIGHT: Steel door framings help lessen need for high-cost carpentry. Note corrugated steel above used as forming for the roof.

FILE: Architectural

stand winds up to 180 miles an hour. Hence the interest of builders from the hurricane-plagued Caribbean areas.

Since even the door frames are steel, the Uni-Con houses are so fireproof and windproof that no fire or wind insurance is considered necessary. This is an economy that makes a strong sales point. "In order to damage the steel-framed Uni-Con house," one of the inventors points out, "the wind would have to pick it up, floor and all, and roll it down the street like a square block of concrete!"

When complete, the houses have a strictly conventional appearance on the outside. The interior, however, gives some indication of the changes wrought by concrete construction. For example, round wall corners, long the bane of the home construction industry, take considerably less labor when steel is used, since the steel is easily formed to the shapes envisioned by the architect.

Here are some of the other advantages claimed for the system: The steel work can be erected quickly and cheaply; it does away with high-priced labor for carpenters and masons, substituting $1.50 an hour labor which can be taught in about two hours to spray on the concrete; even downspouting and eaves can be made of concrete at a $200 saving; the steel-grid framework of the roof is of such strength that it is possible to omit the steel beam commonly used in the ceiling section between kitchen and dining areas.

External facings on some of the houses are fashioned of white cement as the last coat to be sprayed on the steel grid network. A potato-peeler type tool is used to trowel black mortar joints over the entire front of the house, across the whole side of the garage and below the front windows, thus simulating expensive stone masonry. This work is done just before the facing acquires its initial set. This is said to save at least $400 over standard stone construction while achieving the same appearance.

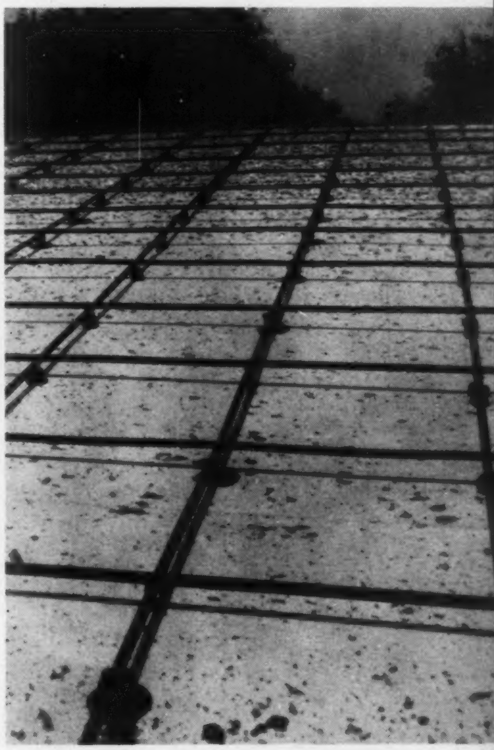
While basically the steel grids in the house run about 12 inches square, on the roof grids 6 inches by 6 inches or more are used, as considered necessary. Corrugated steel sheathing instead of conventional plywood is shored up to support workers while the first coat or two of concrete is sprayed onto the steel rods that form the roof foundation. The steel decking is removed to another job when the roof becomes self-supporting.

The Uni-Con system has been approved for FHA financing. Although the technique has been used only in Florida, where there is admittedly a greater acceptance of concrete than in others parts of the United States, the developers feel that there are actually no area or climate limitations. END

Readers who would like to contact developers of the Uni-Con Process may do so by writing on their business letterheads to Concrete Construction Publications, Inc., P. O. Box 444, Elmhurst, Illinois.

RIGHT: The roof structure shows spaces holding the polystyrene insulating slabs away from the steel rods, to permit the sprayed concrete to fill the spaces and form a solid bond to the steel. Same method is applied to the walls.

BELOW: Builders soliciting a franchise shoot Polaroid pictures as guides for using the process in their own housing operation. The developers claim that unskilled workman can be taught to operate spray nozzle in about 2 hours.



320-foot prestressed bridge

The $1,968,000 Oneida Lake Bridge, a major link in the Empire State Interstate Route 505 between Binghamton, New York, and the Canadian border through Watertown, New York, is a milestone in prestressed concrete construction. When completed in 1960, its 320-foot span will be one of the longest prestressed structures in the world.

The bridge consists of two separate parallel structures, 56 feet center to center, carrying three lanes of traffic in each direction. Each structure is made of twelve 146-foot cantilever girders which carry five 231-foot girders hung between them. Under live load this becomes a three-span continuous structure with continuity achieved by post-tensioning transversely at ends of cantilever. All the members are post-tensioned concrete monoliths. Careful attention to concrete mix design provided workability without excessive water and retarding of setting until each girder was cast, thus preventing cold joints, and assured uniformity in concrete in spite of varying temperatures.

Photo shows workmen for Terry Contracting spraying burlap for curing concrete drop-in girders at the east bank of the north approach. Girders were moved beneath the bridge on a car float and lifted into place between the cantilever girders. Transverse tensioning then tied together the entire system which had been partially counterweighted.

tunnel project

Workers carry sheet of 2 by 4¼ welded wire fabric into south portal of northbound tube, Fort Pitt Tunnels, Pittsburgh, Pennsylvania. Length of fabric is half-tunnel width, will be turned 90 degrees and placed on plywood forms, supported by one-inch chairs as reinforcement of ceiling slab. Workers are walking on 50-foot steel plywood-faced forms.

Ceiling of each tube is a 5½-inch thick reinforced concrete flat slab, suspended 14 feet above the roadway and closing off a 7½-foot high arched space below the actual tunnel lining which is to be a fresh air channel. Two unusual design features of the slab are its means of support: projections of the arch spring line of the tunnel on either side providing supporting shelves; and stainless steel hangers bolted to inserts in the arched tunnel roof suspending the double bulb angles at the center of the ceiling slab.

Owner: City of Beverly Hills, Cal.; **Architect:** Welton Becket & Associates, Los Angeles, Cal.; **Consulting Engineers:** T. Y. Lin & Associates, Van Nuys, Cal.; **General Contractors:** C. L. Peck, Los Angeles, Cal.; Ellis E. White Co., Los Angeles, Cal.; **Precast Columns & T's:** Wailes Precast Concrete Corp., Sun Valley, Cal.

PLASTIMENT increases workability of lightweight concrete

The five-story Beverly Hills Garage illustrated above, providing parking space for 400 cars, is a unique precast, prestressed structure. Long spans of 75 feet eliminated columns in parking areas and use of lightweight aggregate minimized both horizontal and vertical loading.

Use of Plastiment Retarding Densifier increased the workability of the Ridgelite lightweight concrete thereby assuring a smooth, clean appearance to the exposed concrete members. Using high early cement, strengths averaged over 3,500 psi in 16 hours in the precast elements. Slab concrete placed at the site reached 3,500 psi in 2 days. 28-day strengths averaged 6,500 psi.

Mix contained 7-1/2 bags of cement per cubic yard and 2 fluid ounces of Plastiment per sack of cement.

Plastiment features are detailed in Bulletin PCD-59. Ask for your copy. District offices and dealers in principal cities; affiliate manufacturing companies around the world. In Canada, Sika Chemical of Canada, Ltd.; in Latin America, Sika Panama, S. A.

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book reviews

Construction Estimates and Costs, Third Edition. *By H. E. Pulver. Published by McGraw-Hill, 327 West 41st Street, New York, N. Y. 640 pp. Illus. $12.00.*

How to estimate the cost of any type of construction job—either light or heavy—is covered in detail in a newly published revision of a book that has been in use for the past twenty years.

Various aspects of construction work, such as handling and transporting materials, excavation, piling and bracing, concrete, masonry, wood work, structural steel, roofing, heating and air conditioning, plumbing, electrical work, lathing and plastering, and painting are covered in considerable detail.

Each phase of construction work is presented separately, and simple arithmetical methods for accurately estimating costs are described and illustrated. Every step of the work is covered—from preliminary investigation through approximate estimates to complete detailed estimates that include overhead, material, labor and equipment costs, and profit. A new method for computing equipment ownership and operating costs is included.

Industrial Architecture: An Analysis of International Building Practice. *Published by F. W. Dodge Corporation, 119 West 40th Street, New York 18, New York. 240 pp. Illus. $14.75.*

A comprehensive and stimulating review of the basic principles and newest developments in factory design in the United States, Great Britain and Germany, this book covers the history of industrial building design, examines its present state, and emphasizes changing trends and their implications for the future. Every aspect of industrial architecture including functions and needs, utilities, services and structural elements, physical appearance and location are considered and the important role of the architect in the future of industrial building is emphasized. Over 250 striking sketches and photographs of the best work of leading industrial architects and engineers are included. The book is generally non-technical and is equally comprehensible to architects, engineers, and industrial managers and executives.

Highway Engineering Handbook. *Kenneth B. Woods, Editor-in-Chief. Published by McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, New York. 1696 pp. Illus. $25.00.*

A comprehensive handbook on modern highway engineering covers such topics as finance and administration, route selection and layout, soil mechanics, testing, highway materials, basic highway design, rigid pavements, flexible pavements, maintenance, and landscaping. Material on design of pavements to resist slipperiness, the distribution of soils in North America, frost and permafrost as it affects highway design, photogrammetric techniques and many other aspects of the subject make the book helpful to highway and traffic engineers, contractors, materials producers, and all others with a stake in today's expanding highway program.

letters

perlite stucco?

Sir:

I have several block houses I would like to stucco, using something that is light in weight. Would you recommend using perlite instead of sand? I have used perlite in plastering but never to stucco on the outside. Any information on this would be appreciated. Please give the ratio of the mix if satisfactory for outside stucco use.

EDWIN GRAHAM
Kansas City, Missouri

in reply

Sir:

In reply to Mr. Graham's inquiry, perlite stucco has been used quite successfully in exterior plaster. One of the most outstanding examples of this was the 10-story Carson-Union-May-Stern building at 11th and Olive Streets, St. Louis, Missouri. In this application, the perlite stucco was applied over metal lath to the weatherbeaten brick and brownstone face of this structure to provide the combination of insulation and modern appearance.

A recommended mix would be in the ratio of 3 cubic feet of perlite to 1 bag of portland cement. For an exterior application such as this, it is also recommended that the surface be weatherproofed in some manner such as a finish coat of white portland cement paint.

RICHARD E. BARNES
Technical Director
Perlite Institute
New York, New York

products

equipment maintenance

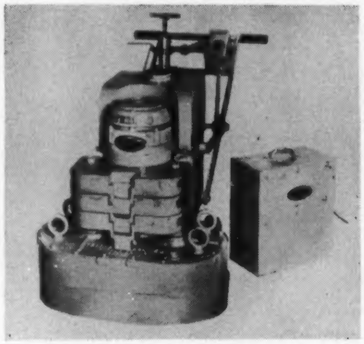
"Henry's Crawler" is the title of a manual in cartoon format designed to encourage operator acceptance of instructions on care and maintenance of equipment. The comic approach provides a means of emphasizing this important subject in a way employees are sure to read and appreciate. J. I. Case Co., Racine, Wisc.

underwater construction

Frogman of the Canadian firm, International Underwater Contractors, Ltd., uses an all-purpose sinker drill for drilling 1⅝-inch holes for concrete reinforcing rods in cofferdam construction. Air drills were used to insert cinch anchor double-unit lead rings to fasten rods in place. This contractor has used other power tools from this manufacturer in underwater work. Thor Power Tool Co., Aurora, Ill.

fall tool bulletin

The 1960 fall bulletin, "Tools for the Trowel Trades," lists a variety of hand trowels, power trowels, tampers, levels, salamanders and other tools, and provides specifications, prices, and order blanks. Goldblatt Tool Co., 1910 Walnut St., Kansas City, Mo.



floor grinding machine

A terrazzo and concrete floor grinding machine can be quickly converted from one- to three-phase operation as desired. It weighs only 479 pounds without weights, making it easy to maneuver. The three-phase feature permits 2 to 3 less amperage draw in starting and running than a single phase under the same operating conditions. The use of fewer integral parts practically eliminates maintenance according to the manufacturer, Terrazzo Machine and Supply Co., 2536 24th Ave., So., Minneapolis, Minn.

jet flame burners

A folder describes 2 LP gas burners which are said to furnish intense, even, immediate heat wherever required. These safe, low-cost burners are useful for heating on construction jobs, and for thawing frozen ground and water lines. They may be used in series for big jobs, or as a portable torch. The 3½-pound model has a capacity of 600,000 btu while the 5½-pound model has a 1,000,000 btu capacity. They are available with or without handles and will perform at full capacity on any size container of bottled gas, under any conditions, according to the manufacturer. Corwill International Corp., P.O. Box 1030, Cedar Rapids, Iowa.

products

better basements

This folder explains why site-cast basements are stronger than other types of construction, why they are more moisture-free, and how they may be finished attractively without plaster or paneling or other wall material. A fourth section is devoted to a comparison of costs which are said to be well in line with those of other construction. Gates & Sons, 80 S. Galapago, Denver, Colo.

handling equipment rental

A 16-page booklet outlining the advantages of renting materials handling equipment features a one-page chart which enables equipment owners to itemize their operating expenses and compare them with the cost of renting comparable equipment. The chart includes factors such as overhead, equipment obsolescence and other expenses often overlooked when determining cost of equipment ownership. Clark Equipment Co., Buchanan, Mich.

stadiums and auditoriums

Concreting problems encountered and solved in the construction of 16 outstanding stadium and auditorium projects in this country and abroad are explained in a 20-page publication, MBR-P-12. The role of an admixture in acquiring the desired handling properties of concrete during placement and to meet exacting requirements for hardened concrete is also stressed. Master Builders Co., Cleveland 3, Ohio.

products

portable heater

A heater with a capacity of 350,000 btu's per hour features a 2-pass stainless steel combustion chamber that is said to burn all objectionable odor and smoke. Air is supplied by a furnace-type blower in place of a fan for positive air circulation and quiet operation. Fuel pump, blower and motor are coupled direct, eliminating v-belts and possible slippage. Heater will operate for 16 hours continuously and longer when equipped with thermostat. White Mfg. Co., Elkhart, Ind.

plumb bob

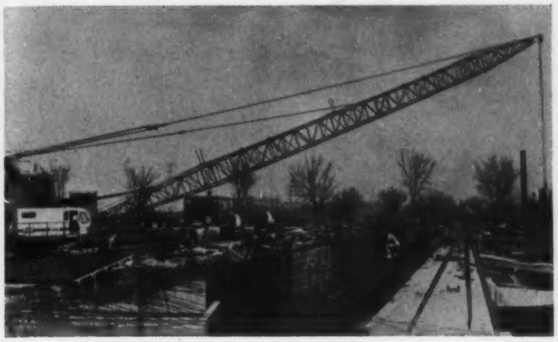
A solid brass plumb bob has a retractable point, spring loaded to absorb impact shocks. The point, of hardened steel, is usable at either end for quick replacement in the field. No tools are required to change the point. A tapered seat assures perfect centering of the point and correct balance at all times, according to the manufacturer. An automatic stop permits scribing. The slimmer body is said to simplify sighting the point and to reduce wind sway. The removable spool cap allows maximum cord storage and its polished edges lessen cord abrasion. C. L. Berger & Sons, 37 Williams St., Boston, Mass.

seismograph

Reliable cost estimates without costly drilling are made available to design engineers, architects, and contractors obtaining subsurface information with a miniature engineering seismograph. The 16-pound electronic instrument provides complete information for precisely determining depth to bedrock, the presence or absence of bedrock or other solid materials, and accurate identification of subsurface materials. Geophysical Specialties Co., 15409 Robinwood Drive, Hopkins, Minn.

vibrating compactor

Compaction on soil equivalent to a 16-ton static weight roller is provided by a 13-inch self-propelled high frequency machine designed to provide compaction in close quarters of trenches, ditches, around foundations, and in almost inaccessible backfilling operations. Powered by a 4.8 hp air cooled engine, and equipped with a separate clutch to allow operation with or without the vibrating mechanism engaged, compactor propels itself at up to one mph in either forward or reverse directions, requiring only guidance by the operator. Essick Manufacturing Company, 1950 Santa Fe Avenue, Los Angeles, Calif.



crawler crane

Crawler crane has a lifting capacity of 110 tons and can handle booms up to 300 feet in length. Photo shows the crane swinging a one-cubic-yard bucket of concrete (5,000 pounds) into place with a 200-foot boom during placing of aeration tanks for Chicago's new sewage treatment facility. Long reach crane enabled contractor to place all concrete for 410- by 290-foot wide rectangular tank and 8 circular settling tanks from outside perimeter, without affecting the construction of forms and reinforcement. Harnischfeger Corp., 4444 W. National Ave., Milwaukee, Wisc.

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the manufacturers listed in the columns below!

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